Influence of cooling systems on the behaviour of dairy cows housed in cubicle barn

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INFLUENCE OF COOLING SYSTEMS ON THE BEHAVIOUR OF DAIRY COWS HOUSED IN CUBICLE BARN

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ABSTRACT During summer 2009 and winter 2010 experimental trials were conducted on order to verify the behaviour of dairy cows in a farm located in Po Plain (Italy). The barn was equiped with an air-water cooling system, based on the use of fans and sprinklers placed in the feeding alley only. Two different trials were carried out. The first experiment targeted the verification of cubicle use by cows in relation to the availability of the cooling system in feeding area. The second trial aimed at testing the effectiveness of zone cooling systems placed in the front of the cubicles. For this purpose three cubicles in the barn were provided with cooling systems, based on the input of high velocity conditioned air streams. The results clearly demonstrated that the behaviour of the animals was greatly influenced by the environmental conditions. With high temperatures the use of the cubicles is deeply reduced and the animals prefer to stay in feeding area, thus benefiting from the cooling effect of water sprinkled by the showers and the air streams created by the fans. With air temperatures increasing from 21° to 33°C the cows reduce time spent in the cubicles, which went down from 52.0 to 29.2% (r^2 = 0.8471). With regards to the efficacy of zone cooling systems in the cubicles, the results are not particularly encouraging. The cows continue using the cubicles without changing the behaviour in relation to the presence of conditioned air flow.

Keywords: Dairy cows, Behaviour, Cooling systems, Cubicles.

INTRODUCTION Dairy cows change their behaviour in relation to environmental conditions inside the barn. Particularly with high summer temperatures the cows search for the greatest thermal comfort areas in the facility, thus limiting the utilization of some areas. A wide international literature is available on this topic. A strict relation between environmental parameters and animal movement has been remarked by researchers. Italian authors (Provolo and Riva, 2009) has outlined that the proportion of cows resting in stalls during daytime, not affected by milking or feeding, rises from 30% in hot periods to 75% in winter time. THI strongly influences the total proportion of lying cows.

Perrisinotto *et al.* (2006) have found that cows spend more time near sprinkling systems, especially in the feeding area.

Several studies remark the usefulness of cooling systems for cows in a warm climate (Armstrong *et al.*, 1988; Bucklin *et al.*, 1991; Lin *et al.*, 1998; Turner, 1998; Frazzi *et al.*, 2000).

Some researchers have tried to realize cooling systems for specific restricted areas. Hillman *et al.* (2000) applied a system able to give little amount of water directly on the cows resting in cubicles, minimizing bedding wetting. Hayasaka *et al.* (2002) have found a higher cubicle use by the cows with localized air flow systems placed 1.10 m above the front edge of cubicle floor.

MATERIALS AND METHODS

During summer 2009 and winter 2010 experimental trials were arranged to verify the behaviour of dairy cows in a farm located in Po Plain (Italy), near Mantua.

The loose barn is arranged with four rows of cubicles and a feeding alley; 40 cows are kept in the barn. Figure 1 shows the layout of the barn. Alley 1 is placed in the middle of the barn, alley 2 is placed in the western side of the barn.

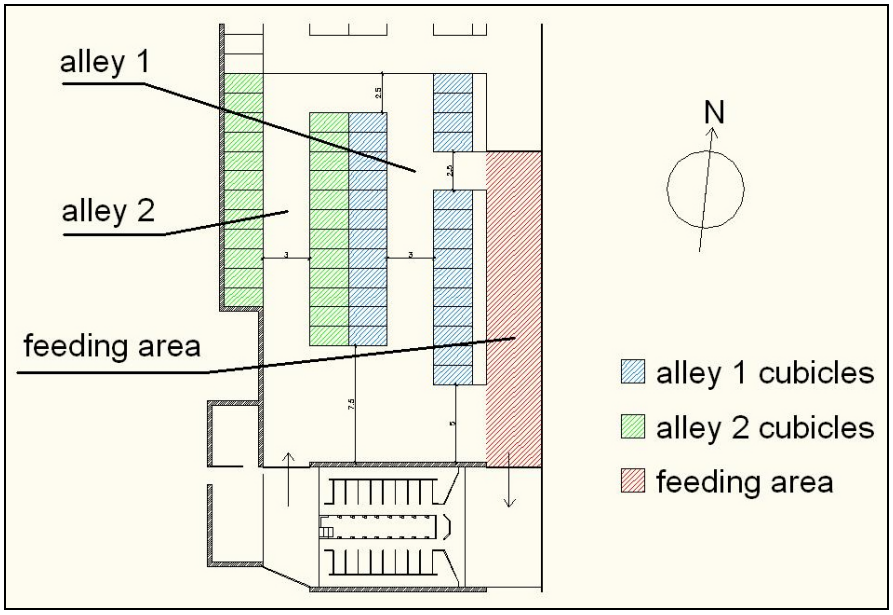

Figure 1. Layout of the loose barn object of experimental trials.

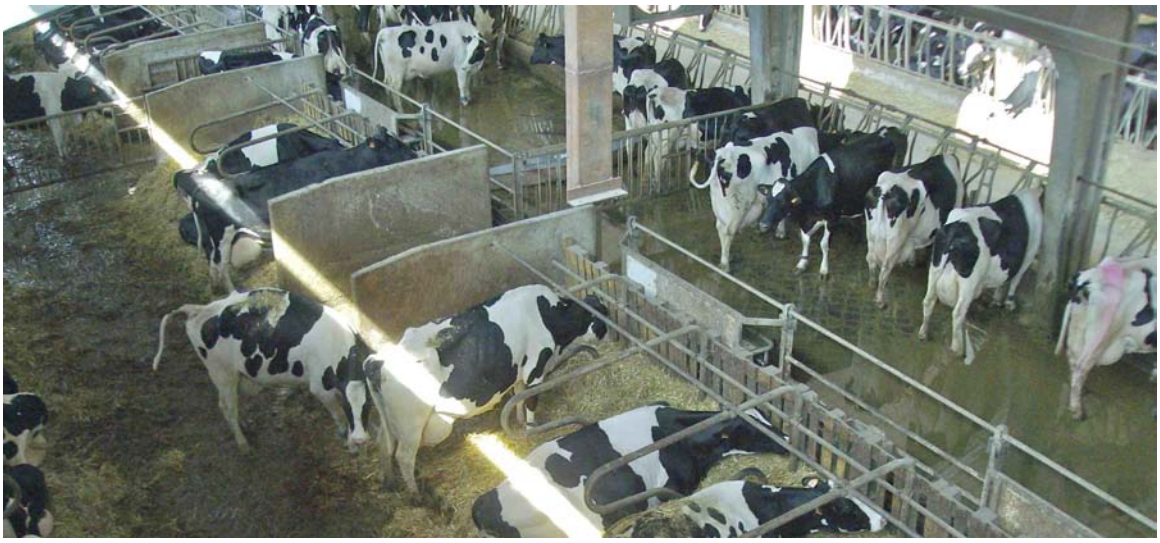

Figure 2. View of the loose barn object of experimental trials.

The barn is provided with an air-water cooling system, based on the use of fans and sprinklers placed only in the feeding alley. Nine fans placed at a distance of 5 m each other are used to create air streams in the feeding alley (1.50 x 1.50 m width, 0.56 kW power). The showers are placed over the body of the cows, when they are located with the head in the rack. Fans and sprinklers are synchronized and start together at time intervals variable in relation to inside air temperature.

Figure 3. Loose barn object of experimental trials. Left: feeding alley provided with fans and sprinklers. Right: cubicles with straw bedding.

Two different trials were carried out. The first experiment was targeted on verifying the use of the cubicles by the cows in relation to the availability of the cooling system only in feeding area.

The second trial aimed at testing the effectiveness of zone cooling systems placed in the front of cubicles. For this purpose three cubicles in the barn were provided with cooling systems, based on the input of high velocity conditioned air streams (Fig. 4, Fig. 5). The conditioned air was directed to the head of the resting cows by means of metal pipe

placed at a distance of 1.50 m from the floor. The average velocity of the conditioned air coming out from the openings was 4.25 m/s, the average temperature of the air at the openings was 20.5°C (with air temperature inside the barn of 29.3°C). The trial was repeated in cubicles on alley 1 and in cubicles on alley 2.

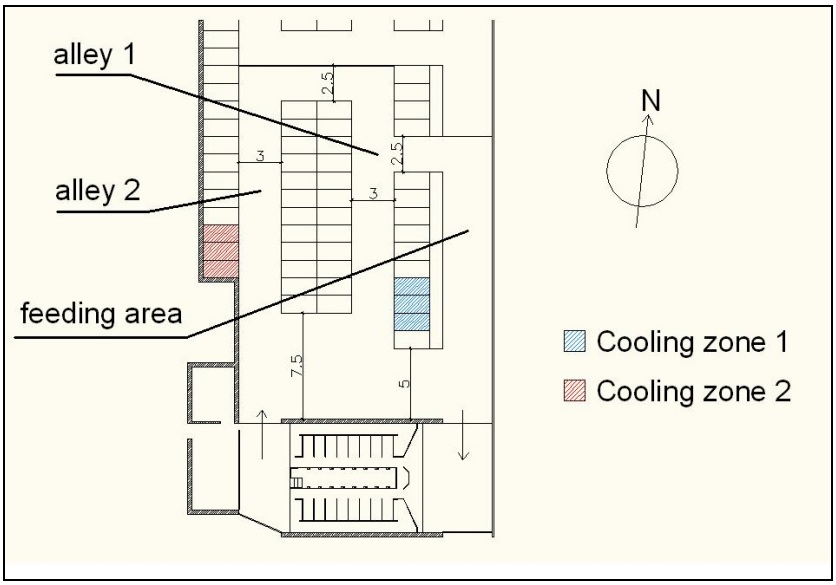

Figure 4. Layout of the barn object of trials with localized air cooling system.

Figure 5. The experimental localized air cooling system applied in three cubicles.

The experimental trials were carried out in two periods of the year, summer (29th July – 18th August, 2009) and winter (28th December, 2009 – 12th January, 2010). Different kinds of data loggers were used to collect environmental parameters: air temperature and relative humidity outside and inside the barn in different points; air velocity inside the barn. A digital closed-circuit television system with infrared cameras was applied to monitor the behaviour of the cows inside the building, allowing us to evaluate the time spent by the cows resting in cubicles, moving in the alleys, staying in feeding area.

RESULTS AND DISCUSSION

The results of experimental trials carried out in the barn are shown in figures 6 to 14.

Figure 7 remarks the different behaviour of the cows in winter and summer. The behaviour of animals can be put in relation with the thermo-hygrometric conditions inside the building for the "typical" winter and summer days represented in Fig. 6. The different use of feeding area in the two compared situations clearly appears. In summer the cows stay for long periods during the hottest hours of the day in feeding area in order to benefit of cooling system. Consequently the time spent by the cows resting in cubicles is much lower in summer than in winter season.

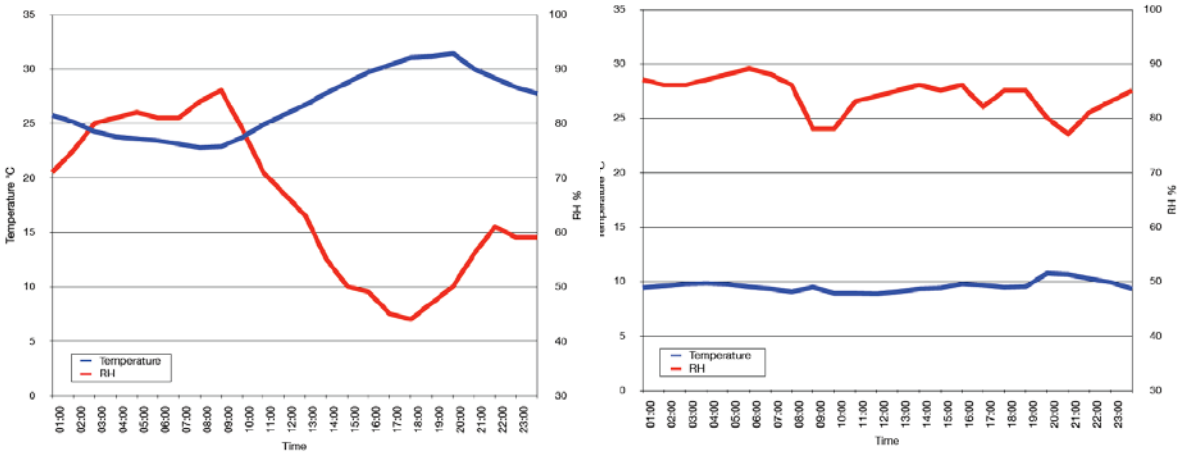

Figure 6. Air temperature and RH in "typical" day of winter (left) and summer (right).

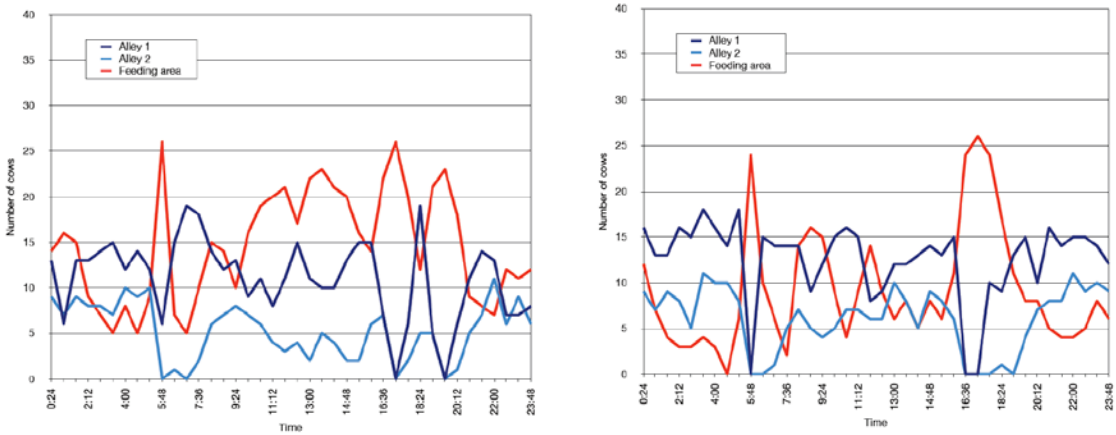

Figure 7. Attendance of cows in the different areas in "typical" day of winter (left) and summer (right).

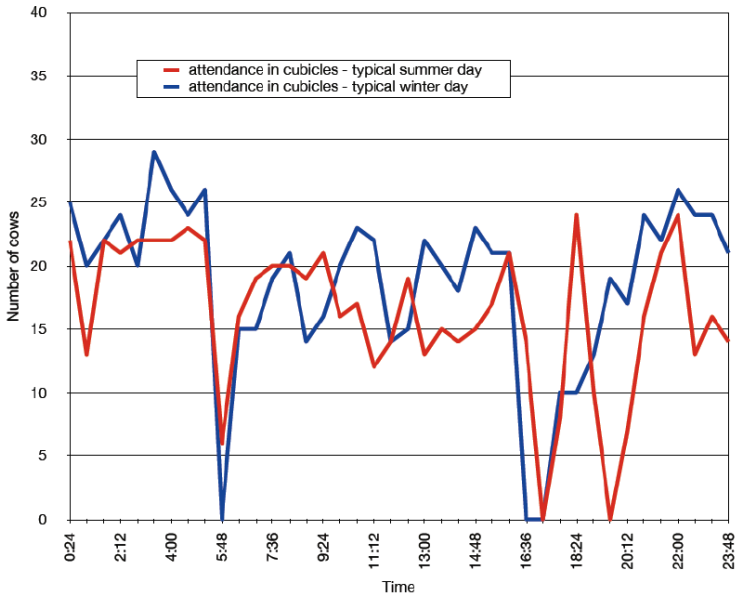

Figure 8. Attendance of cows in cubicles in "typical" day of winter and summer.

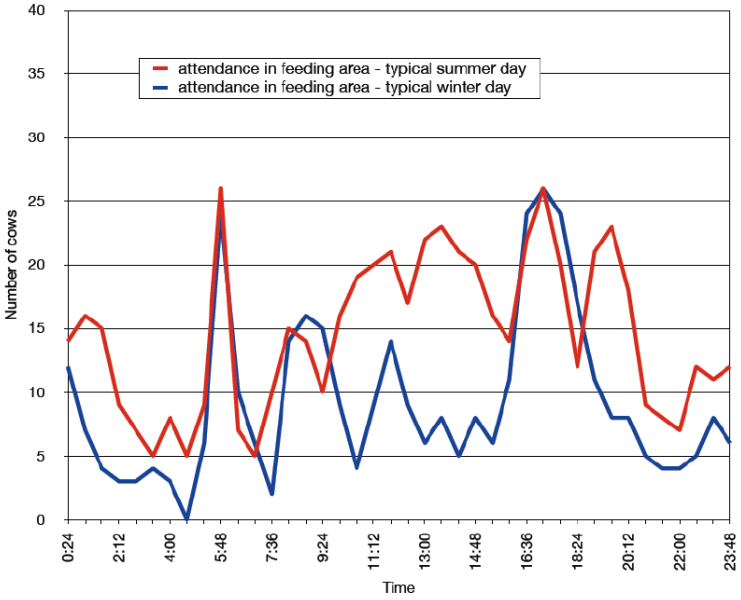

Figure 9. Attendance of cows in feeding area in "typical" day of winter and summer.

The greatest differences in the behaviour of the cows are clearly remarked during the middle part of the day (11 a.m – 5 p.m.). In the graphs of Fig. 10 and Fig. 11 it is possible to examine the differences in the attendance of the different areas by the cows during the period from noon to 4 p.m. It is very evident that during the hottest hours of the day in summer period the cows prefer to stay in feeding area, which is refreshed with air streams and water directly on the body of animal. This behaviour limits the resting periods of the cows.

Table 1. Time spent by cows in cubicles and in feeding area in different environmental situations.

Day	Average internal temperature (°C)	Avarage time spent in cubicles (hours/day)	Average time spent in feeding area (hours/day)
Summer typical day	26,71	9,7	8,7
Winter typical day	9,51	11,2	5,5
Summer hottest day	27,98	9,4	8,6
Winter coldest day	7,11	12,7	5,5

Another important consideration regards the use of the cubicles in relation to the air temperature. The graph of Fig. 12 shows how the use of cubicles linearly decreases with the rising of air temperature in summer period (r^2 = 0,847). The behaviour of the cows changes in winter, when the use of cubicles appears not influenced by the temperature inside the building (Fig. 13).

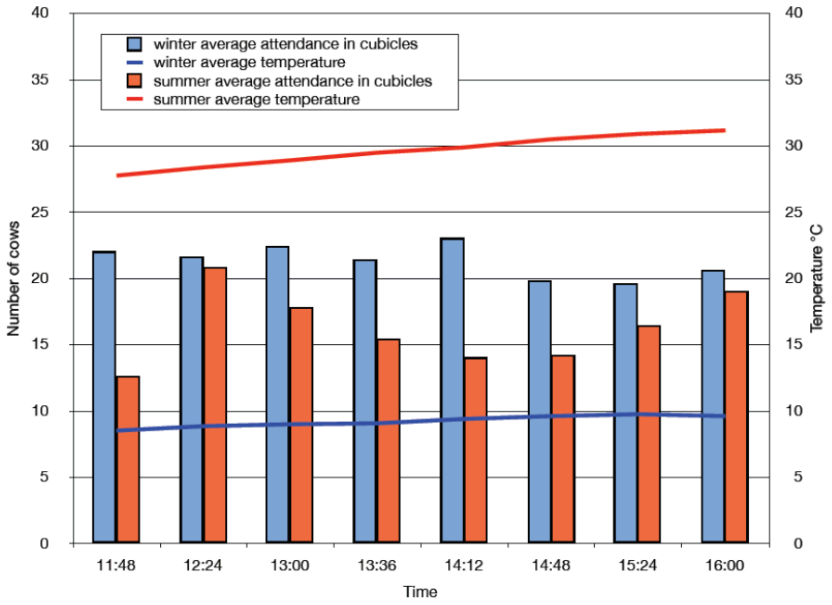

Figure 10. Attendance of cows in cubicles in winter and summer during the period 12-16 (average data of the whole experimental periods).

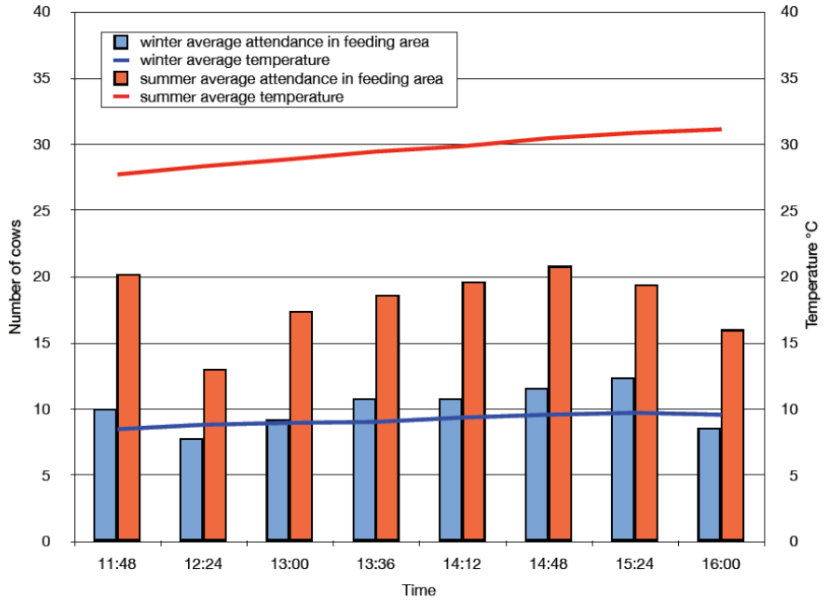

Figure 11. Attendance of cows in feeding area in winter and summer during the period 12-16 (average data of the whole experimental periods).

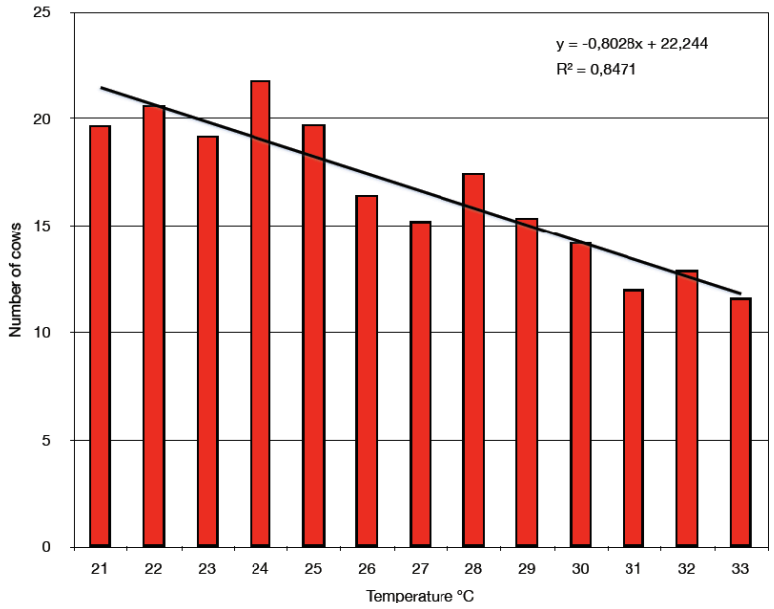

Figure 12. Attendance of cows in cubicles in summer in relation to the temperature (average data of the whole experimental period).

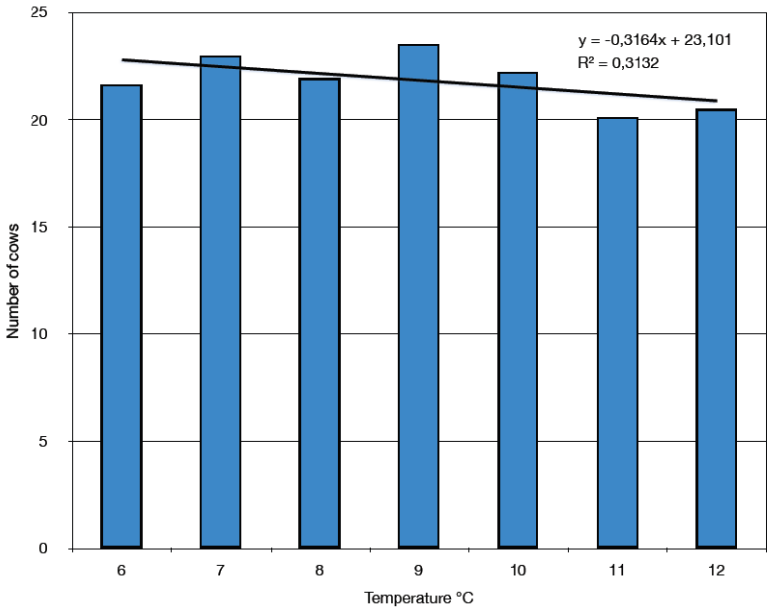

Figure 13. Attendance of cows in cubicles in winter in relation to the temperature (average data of the whole experimental period).

As regards the efficacy of zone cooling system in the cubicles, the results are not particularly encouraging. The cows continue using the cubicles without changing the behaviour in relation to the presence of conditioned air flow (Fig. 14). This negative response could be due to the under-dimensioning of air flows and to the experimental procedures.

Regarding the cubicles placed on alley 2 the cows do not use this resting area at all in the summer season, both without conditioned air and with conditioned air. This behaviour is due to the high values of air temperature reached in the area and to the very low values of air velocity (close to 0).

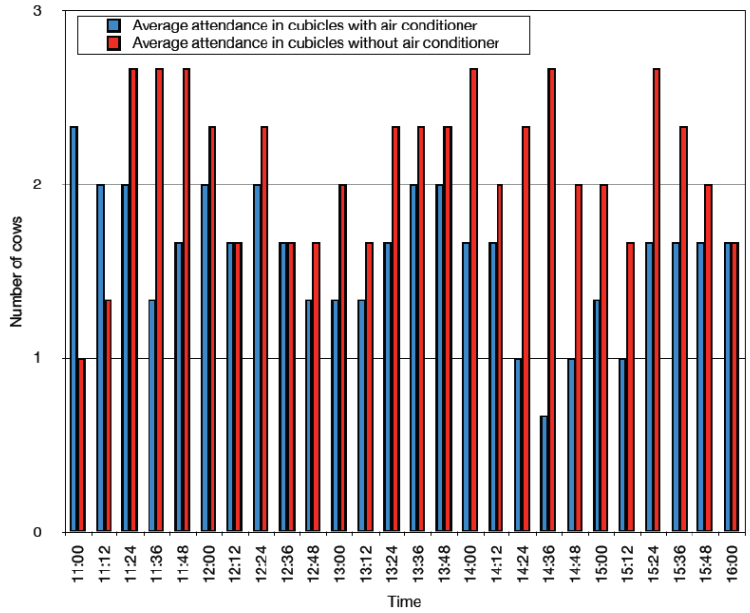

Figure 14. Attendance of cows in three conditioned cubicles in the period 11-16 (average data of the whole experimental period).

CONCLUSION The behaviour of the cows is strictly related to the microclimatic conditions inside the barn. Particular attention has to be paid in the design of cooling systems in a loose barn for dairy cows. The resting period of the animals can be compromised if the environmental conditions are not adequate. If the cooling systems are adopted only in feeding alley the cows prefer to use this area limiting the resting periods.

To favour the use of cubicles by the cows localized systems could be designed, but deep researches have to be carried out in order to define comfortable solutions for the animals, taking into account the investment and running costs.

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